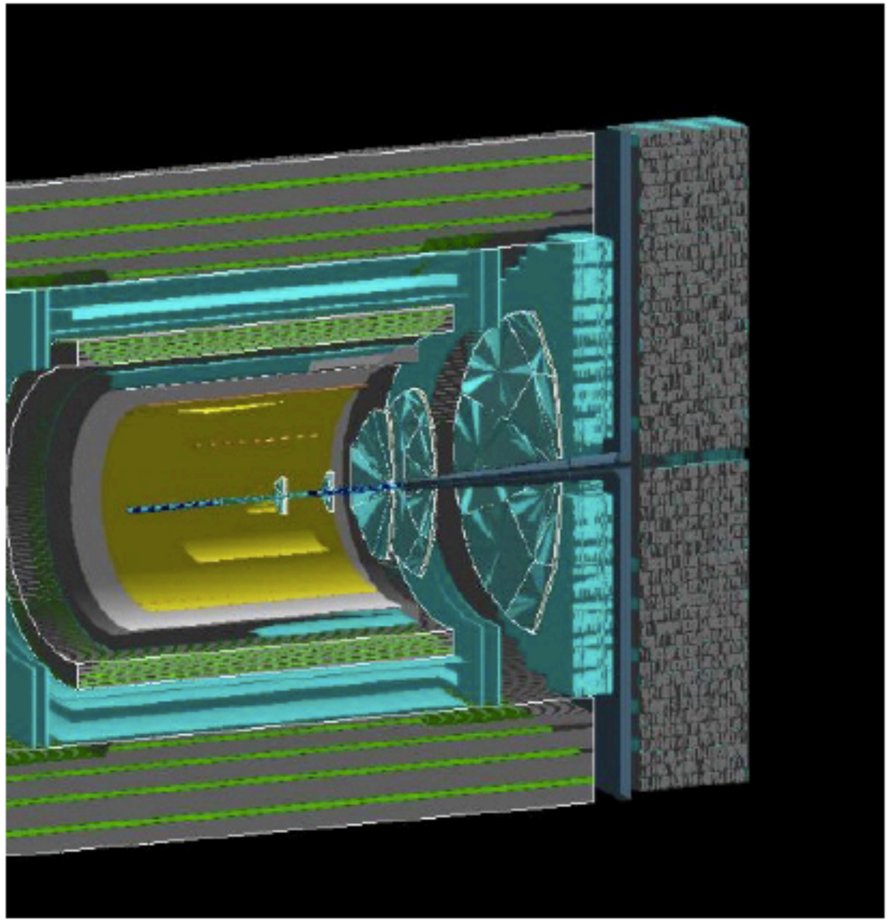
Letter of Intent for Forward Instrumentation at sPHENIX



The sPHENIX Collaboration
June 1, 2017

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Primary physics opportunities

- Study spin-spin and spin-momentum correlations in QCD
  - Forward rapidities are where huge effects have been seen
  - Central-forward photon-jet and dijet measurements, plus measuring hadrons within jets, will give full info on the LO parton kinematics (x1, x2, z, Q^2), for first-ever direct comparison to measurements in semi-inclusive DIS and e+e-
  - Probe universality, effects of factorization breaking/soft-gluon exchange, as well as improving knowledge of nucleon structure
- Search for evidence of gluon saturation
  - Forward p+A to access low-x gluons in the nucleus
  - Via Drell-Yan, photon-jet, dijet, dihadron
- Explore early times in A+A collisions
  - Long-rapidity correlations are imprinted at early times, as long as any subsequent evolution is local (e.g. hydro)—access information on pre-QGP. Look at full 3-D event shapes via forward-central correlations of transverse energy in calorimeters.
  - Long-range correlations in rapidity enabled by coverage from -1 to 4

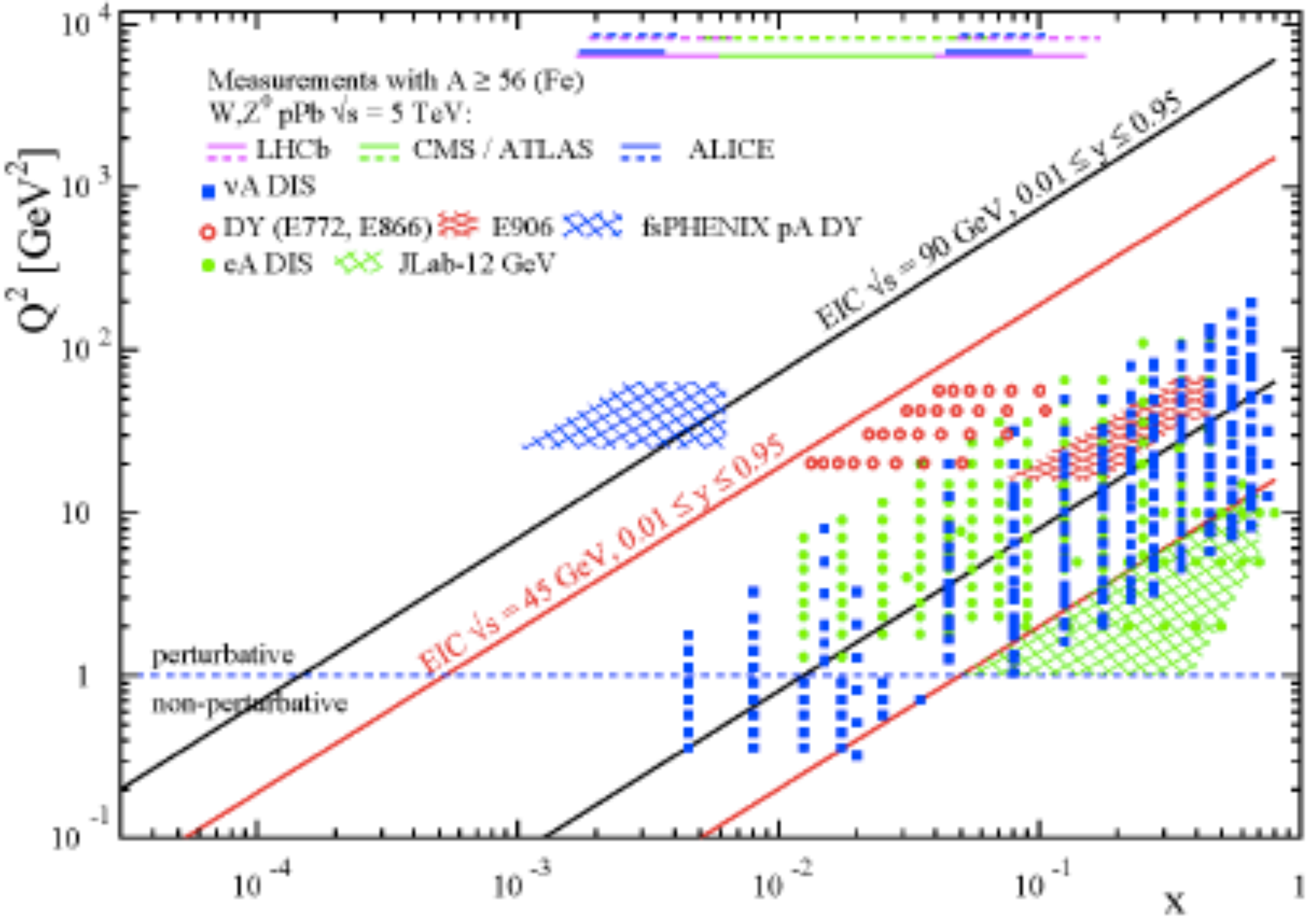


Figure 1.1: Kinematic coverage for DY in p+A at RHIC. This plot needs to be included as it makes the point that p+A provide a unique kinematic coverage compared to the EIC.

Detector Design

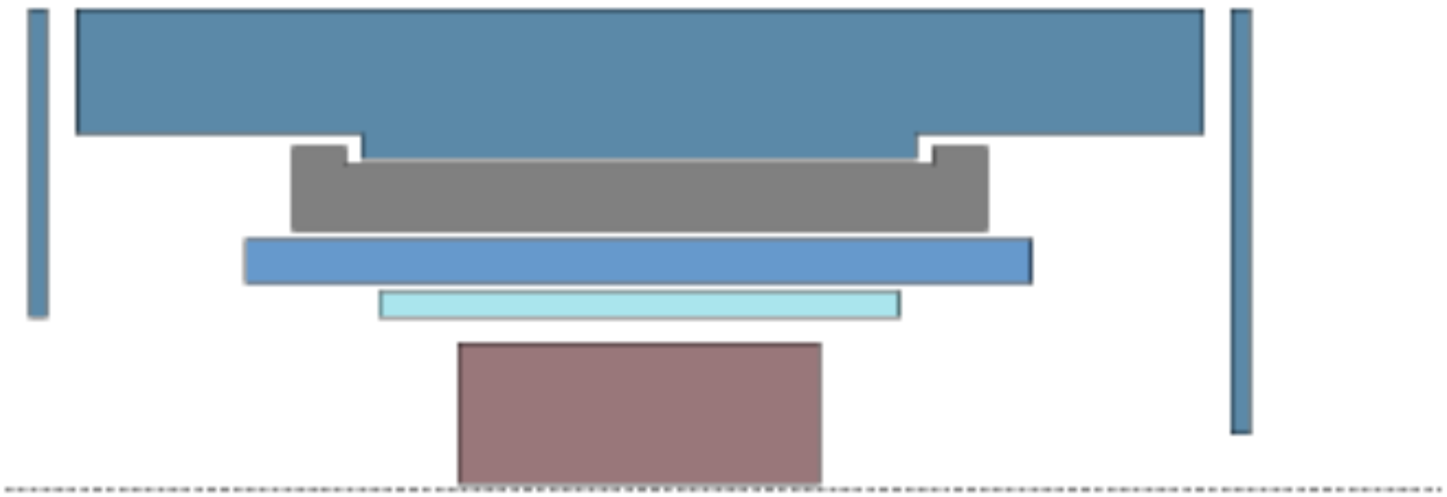


Figure 2.1: The sPHENIX experiment.

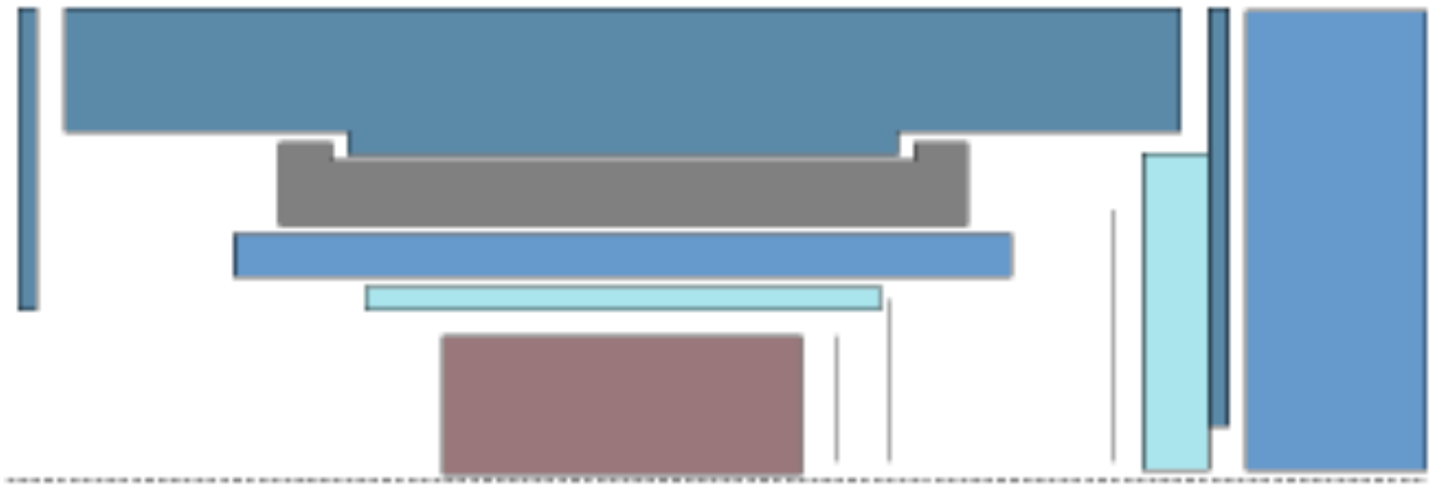


Figure 2.2: The sPHENIX experiment with proposed forward instrumentation.

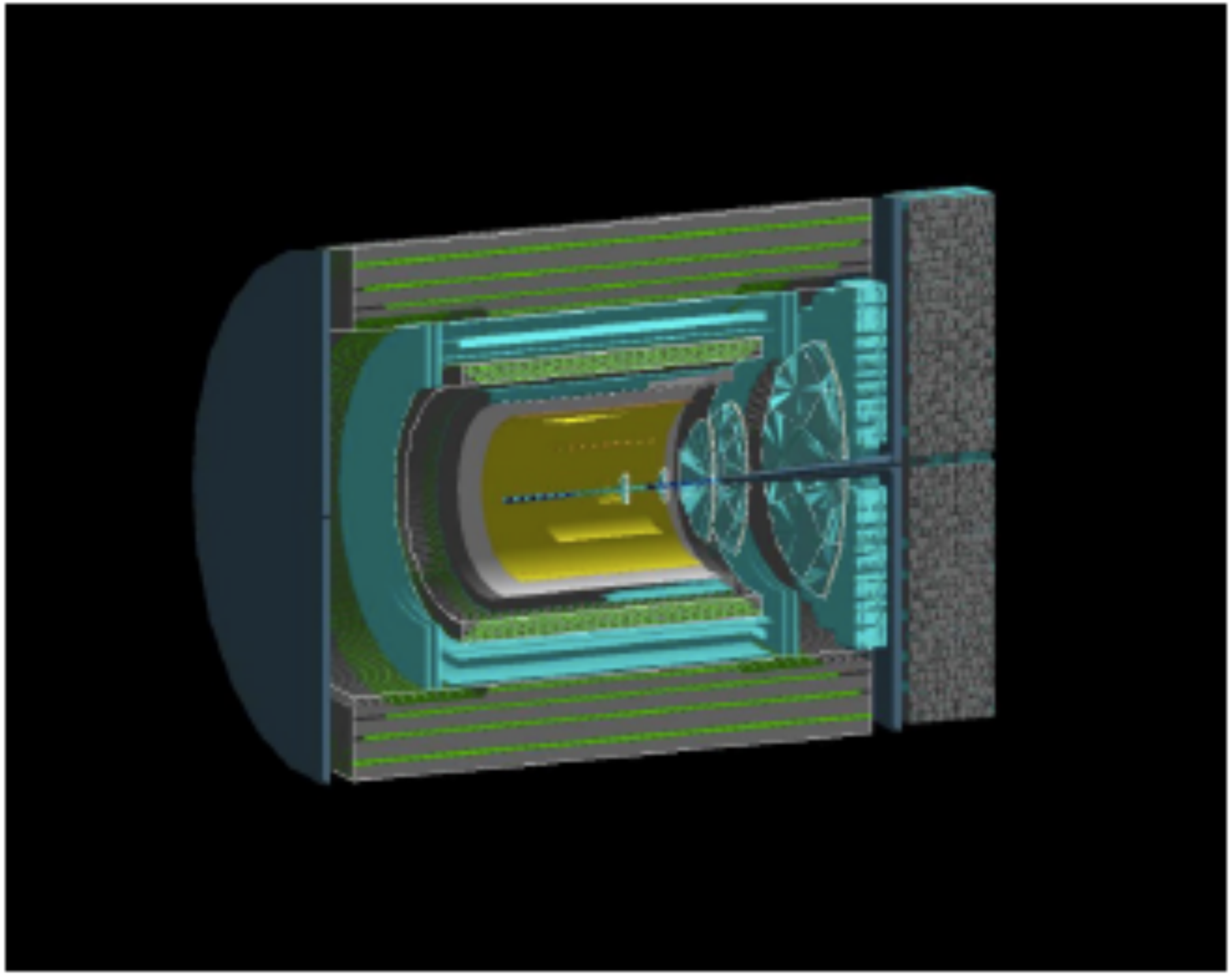


Figure 2.3: The sPHENIX experiment with proposed forward instrumentation in Geant4.

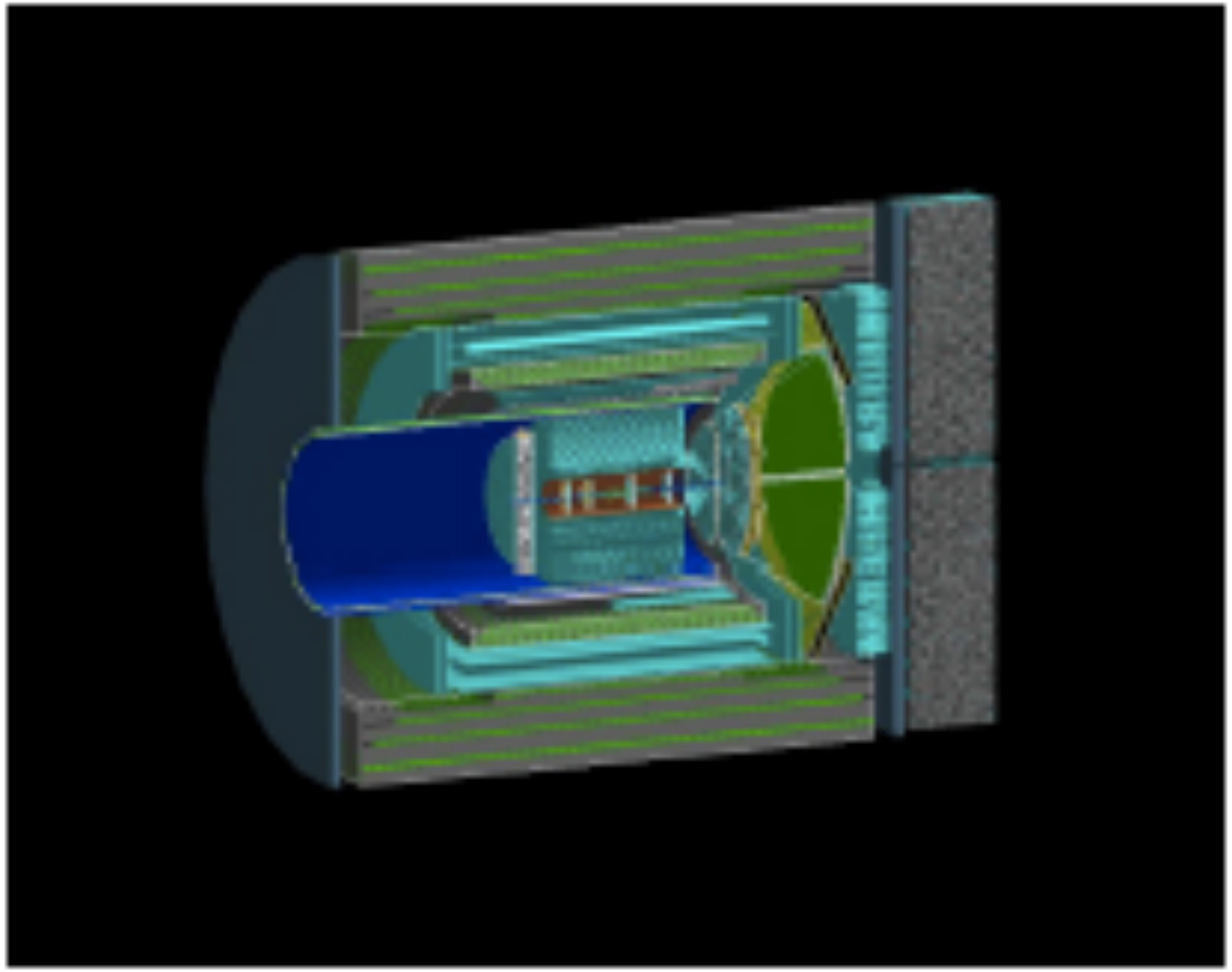


Figure 2.6: The EIC detector based on sPHENIX in Geant4. It reuses the sPHENIX superconducting solenoid and the electromagnetic and hadronic calorimeter system, as well as forward instrumentation.

Detector Performance

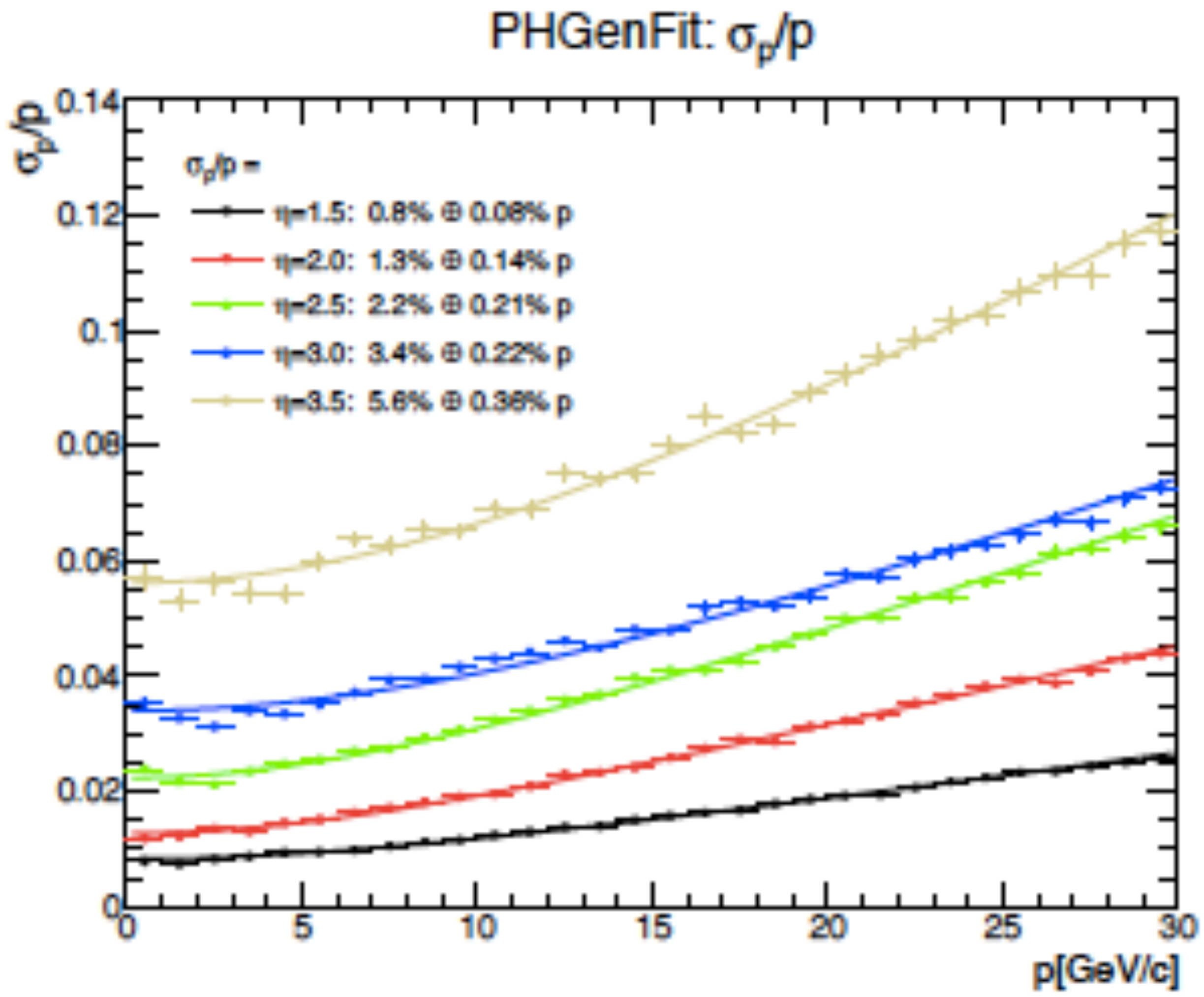


Figure 3.1: Relative momentum resolution for the tracking system plotted against total momentum (NOTE: EPHENIX FIELD MAP, NEED TO UPDATE WITH FSPHENIX MAP).

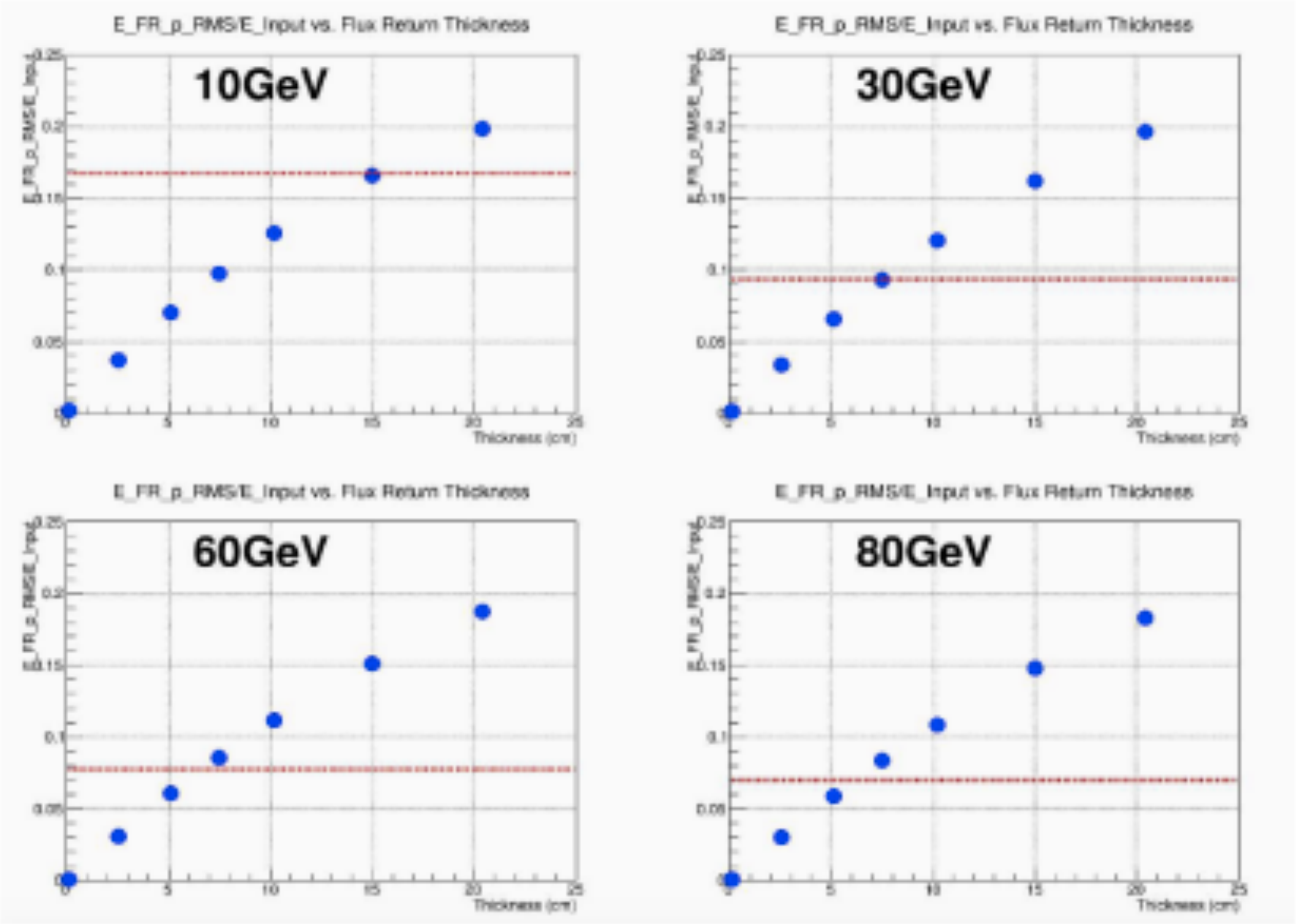


Figure 3.3: The root mean square of absorbed energy in the plug door divided by the particle input energy is shown as a function of the plug door thickness for single 10 GeV, 30 GeV, 60 GeV, and 80 GeV charged pions. The blue dashed line indicates the nominal energy resolution of the calorimeters with no plug door.

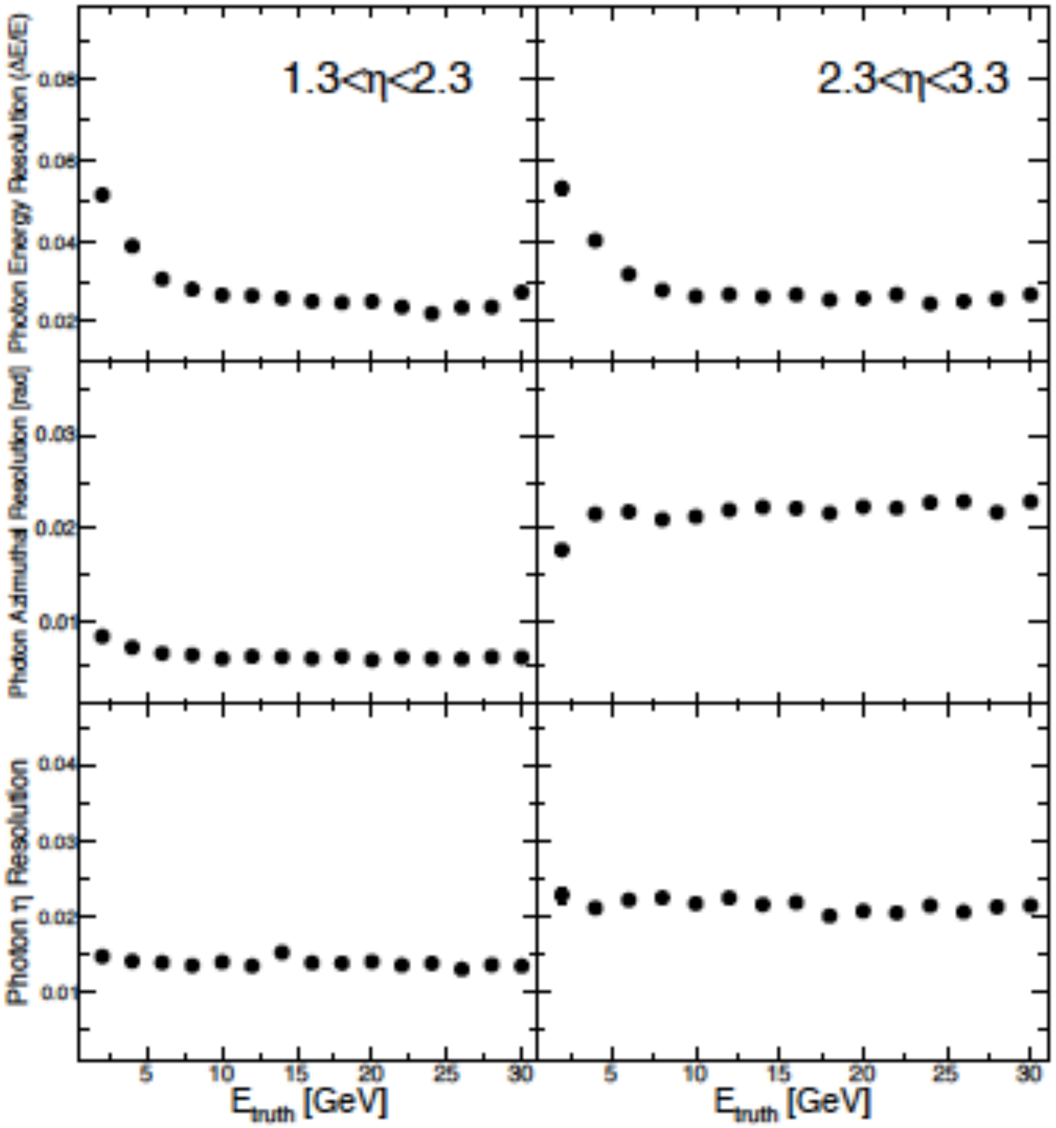


Figure 3.4: The photon energy (top), ϕ (middle), and η (bottom) resolution in the fsPHENIX EMCal. Resolutions were determined by throwing single photons in the nominal fsPHENIX coverage.

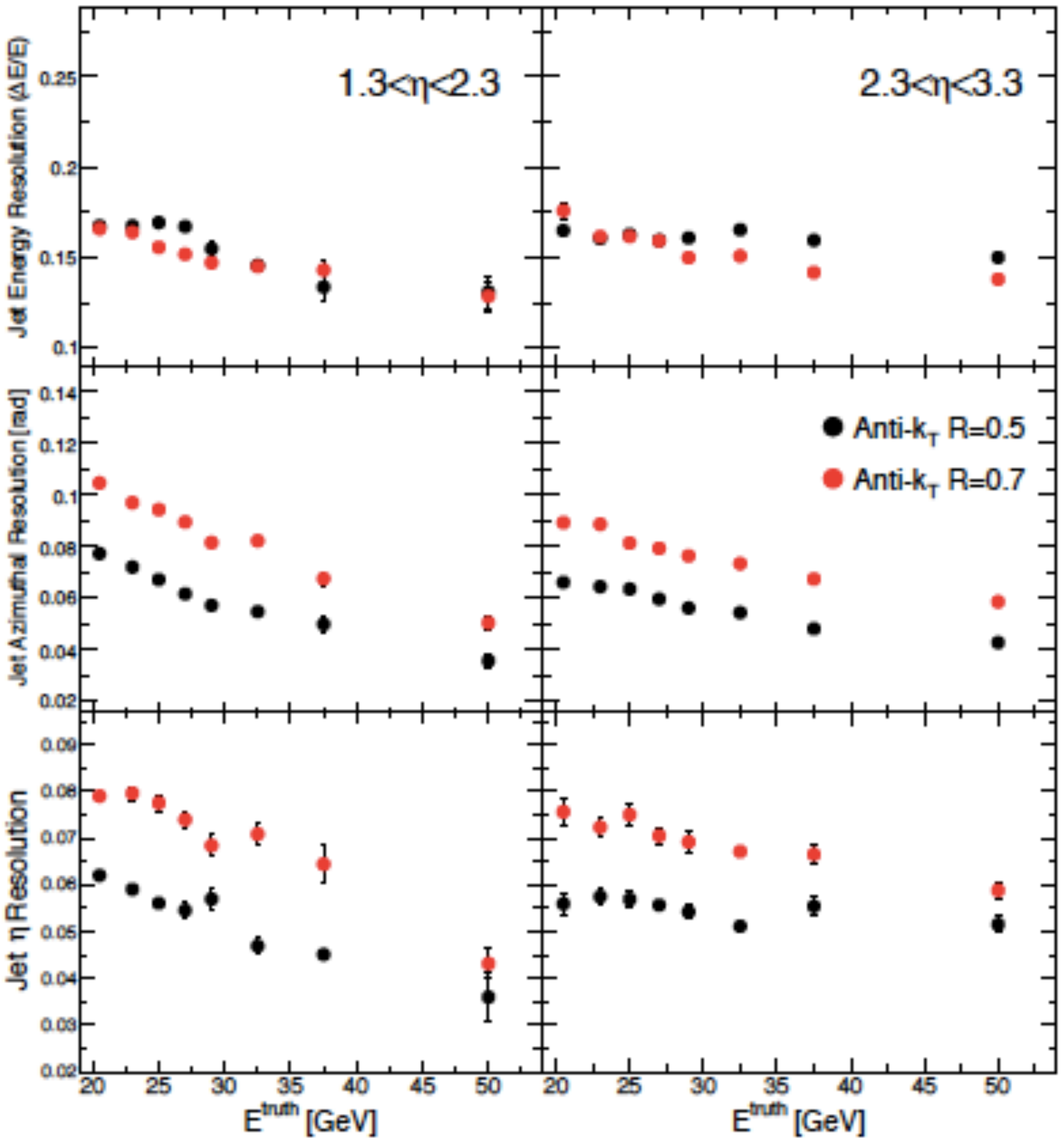
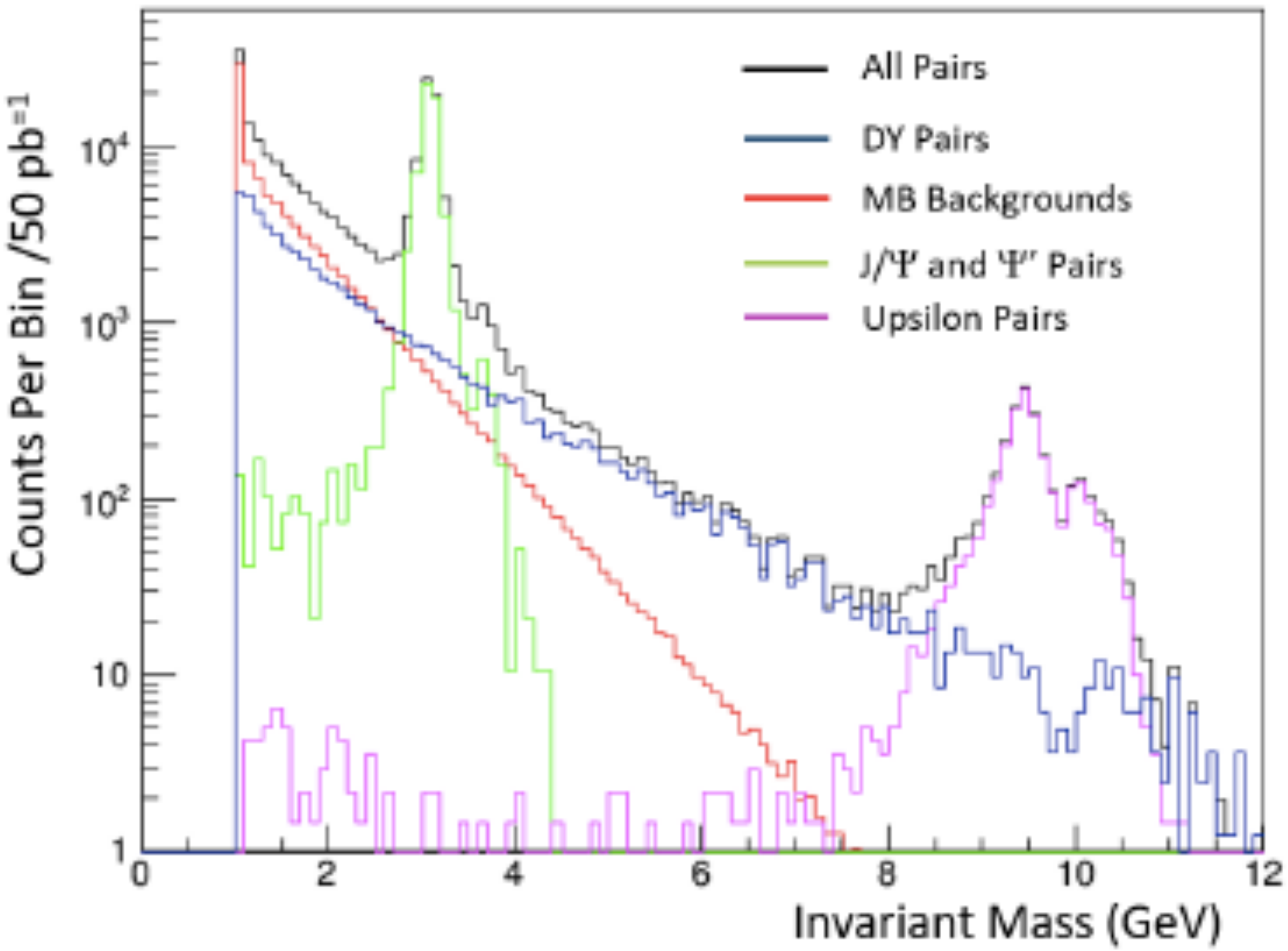


Figure 3.5: The GEANT4 simulated jet resolution of single jets for energy (top row), ϕ (middle row), and η (bottom row) in minimum bias $p{+}p$ collisions from PYTHIA8. Jets are reconstructed using the FASTJET package anti-k_T algorithm with R=0.5 (black) and R=0.7 (red).



Invariant mass spectrum is fsPHENIX obtained with $50pb^{-1}$ of integrated p+p luminosity at 200GeV. The pair sources were simulated using Pythia8 events and a full G4 simulation of the fsPHENIX detector systems.

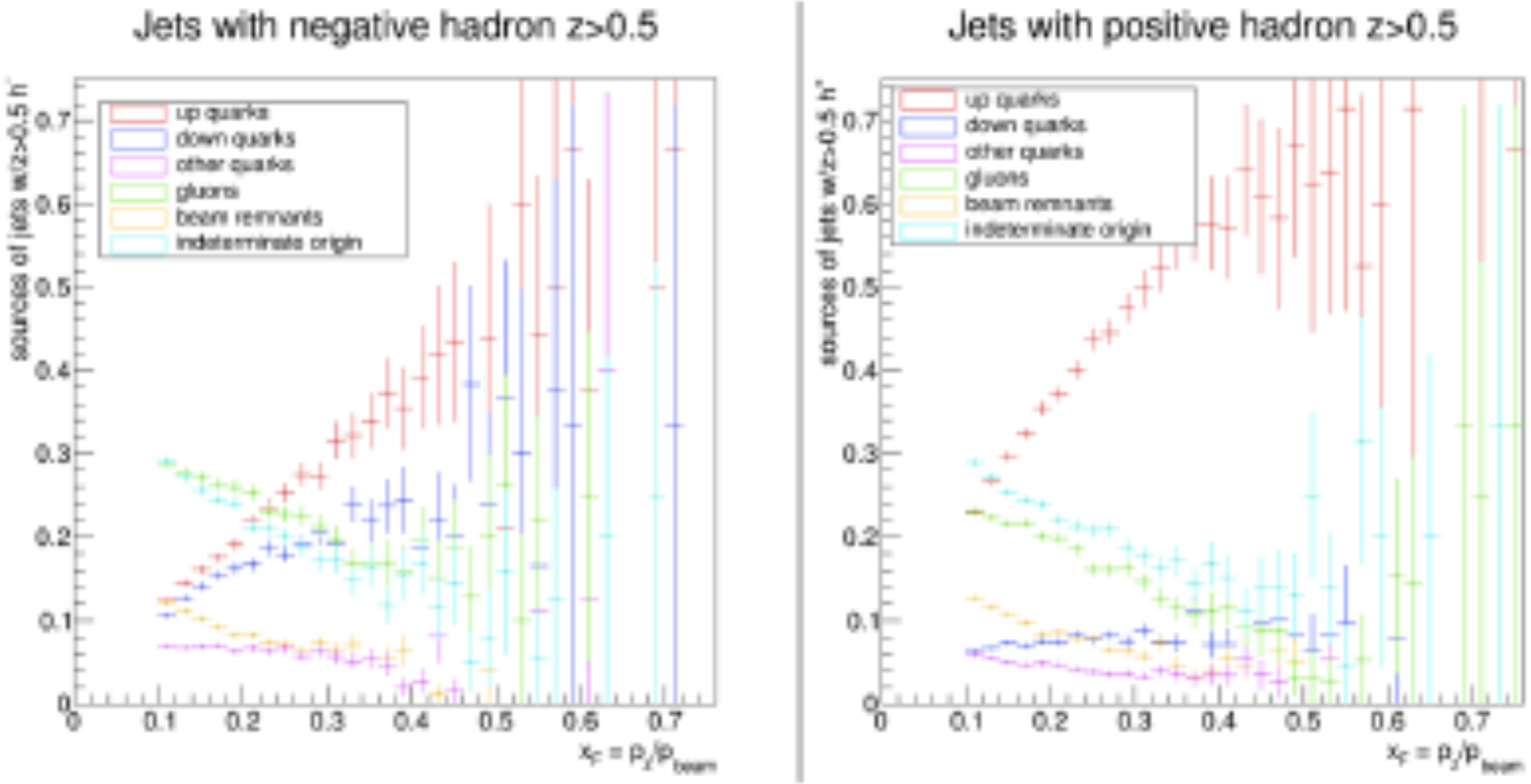


Figure 3.12: Jet sources as a function of x_F at $\sqrt{s} = 510$ GeV in $1.7 < \eta < 3.3$ and $p_T > 5.0$ GeV, reconstructed with an anti-k_T algorithm with radius 0.7. To be assigned to a source, more than 50% of the jet energy must be associated with that source. The left panel shows the jet source bias induced by requiring the jet have a leading particle ($z > 0.5$) with a negative charge, while the right panel requires a positive charge leading particle. These selections vary the influence of u/d quarks in the overall jet sample.

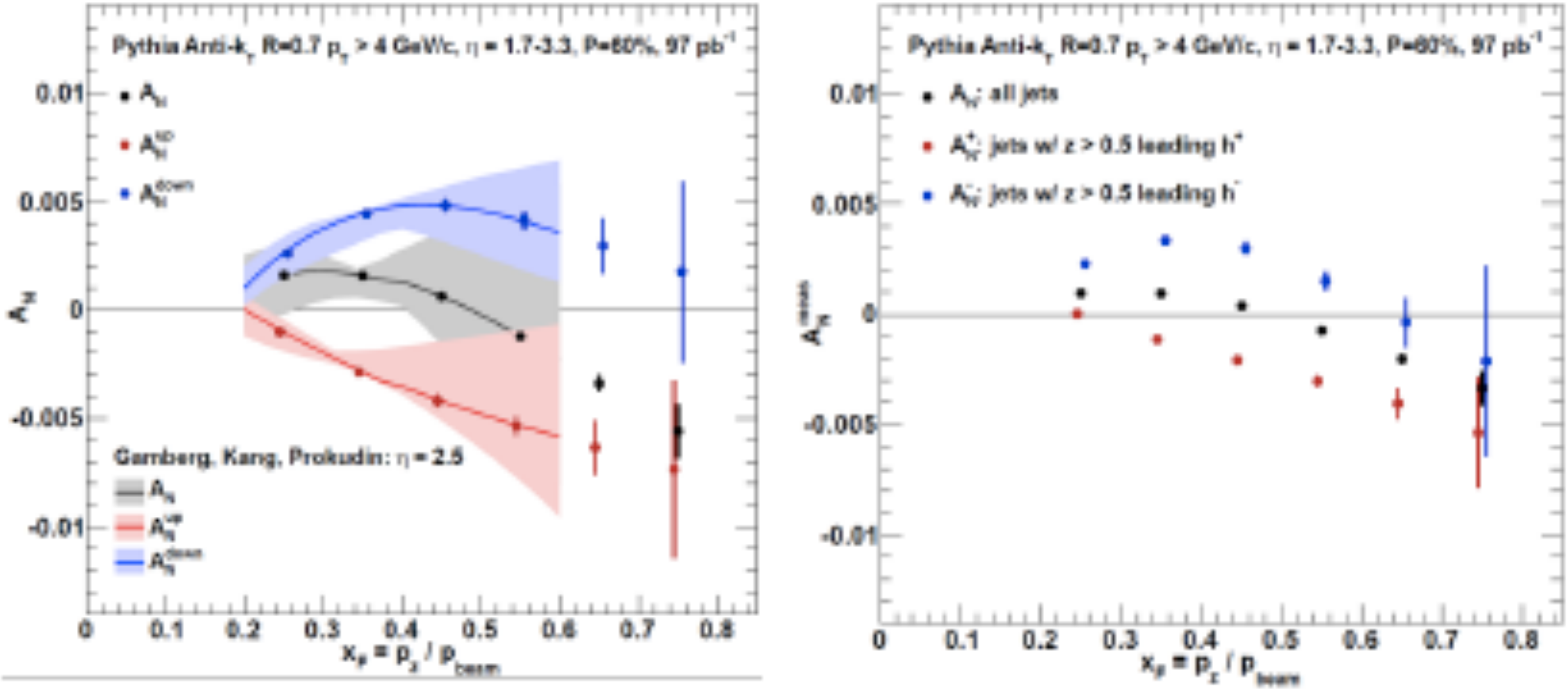


Figure 3.14: (DRAFT - NEEDS TO BE UPDATED) This is the OLD plot from the first LOI, need to be updated for 510 GeV. The 510 GeV u/d quark asymmetries have been requested from Zhongbo Kang 5/9. Once we have these and the addition statistics for the jet fractions we can remake these plots.

Cost Estimate

Evolving…

5/7	5/8	5/9	5/10	5/11	5/12 Today	5/13
5/14	5/15	5/16 Workfest @SBU	5/17 Workfest @SBU	5/18 Workfest @SBU	5/19 Submit to Collaboration	5/20
5/21	5/22 TG Meeting Discuss draft	5/23	5/24	5/25	5/26	5/27
5/28	5/29	5/30	5/31	6/1 Submit to ALD		